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ABSTRACT

In this middle school students' guide poetry, music, fine arts, drama, and movement are used to help teach science students that there are a number of valid points of view about natural phenomena, only one of which is scientific. The limitations on questions for which scientists can seek answers are illustrated by science-fiction accounts of alternate cultural conditions where the ideational framework differs from our own. In these worlds science is not part of the accepted way of looking at nature, or alternate historical choices have been made producing different attitudes toward scientific questions. To indicate the limitations imposed by the finite human mind a series of "mind stretching" exercises involving size and time are included. A teachers' guide is appended. (AL)

W. C. VanDeventer

IDEA-CENTERED LABORATORY SCIENCE

(I-CLS)

Unit F. A Scientist Looks Critically at His World

Many non-scientists have an idea that science has no limit to its accomplishments. "Scientists can do anything," they think. Actually this is not true. The scientist's world and the things that he can do in it are very definitely limited.

In the first place, a scientist's world is limited because it deals only with that which is measurable. It can deal only with quantities. It cannot deal with qualities, or feelings, or values. Of course a scientist, as a person, can be aware of qualities and values and can be ruled by feelings, but when he does so, he is no longer dealing with science.

Again, the scientist is limited by beliefs from the culture to which he belongs. This limits the kinds of things that he can do, even in the measurable world that belongs to science. A scientist may not always be conscious of the limitations that the beliefs that belong to his culture impose on him. He may think he does not have these beliefs, but the fact that they are a part of his cultural background controls his actions even when he does not realize it. He is limited in the kinds of observations he makes, actually in what he sees, and in the interpretations that he makes.

Finally, a scientist is limited by the very nature of the human mind. Man's mind is a finite (limited) mind. It is not capable of grasping the whole of the universe: space, time, or size. It has to make models of things that it cannot see completely. These models are not always accurate because they must be made in the limited terms that man's limited mind can grasp.

This unit is intended to outline some of the limits of the world that the scientist has found.

I-CLS

Unit F. A Scientist Looks Critically at His World

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Idea That a Scientist Is Limited By How He Feels About His World F.1.

Idea Bridge: Things Seem Different When They Are Looked At Differently

It cost many billions of dollars to put men on the moon the first time. Was it worth it? This was an event that ranks among the most important achievements in human history. Children will be reading about it thousands of years from now. Every part of the event can be described objectively and quantitatively: how much it cost; how long it took to get ready for the trip; how large the moon rocket was; how much fuel it consumed; how long it took to make the trip; what were the physical reactions of the men who went (breathing rate, heart rate, blood pressure, et cetera). But were the money, the materials, the energy, the men's time well spent? Should they have been used in some other way? The answers to these questions are value judgments. They depend on how you feel. They are subjective opinions, and are based on something inside of you.

A boy and a girl are looking at a beautiful sunset across a lake. The colors of the sky and the time of day, together with how they feel about each other, combine to make a picture in their memories that they will never forget. At the same time from a point nearby, a photographer is taking a picture of the same sunset. He is making a lasting record of the color patterns and light intensities that can be analyzed and described objectively and unemotionally. The sunset is the same in each case. Only the two ways of looking at it are different.

The world of science is a world of quantities. It is a world that is measurable. Galileo said that "science attempts to measure all things, and to reduce all things to measure." Science deals only with things that can be weighed, measured, counted or otherwise quantitatively described. We say that the world of science is an objective world. It lies outside of the person who is studying it.

Music, art, and certain kinds of literature are related to the person who is studying them in terms of qualities. They belong to the world of the humanities. This is a world of feelings. In it things cannot be weighed, measured, counted, or otherwise quantitatively described. Our reactions toward them depend on how we feel about them. This is a subjective world. It depends very much on what is inside the person who is studying it.

We can say how big a thing is, but we cannot say how good it is. We can count how many roses there are in a garden, but we cannot measure how beautiful they are. Things that can be quantified are outside of us and can be expressed objectively. Things that depend on qualities are inside of us and are subjective.

Our world is filled with things and events that can be looked at both objectively and subjectively, often at the same time and by the same person. In fact there is very little that cannot be and is not looked at both ways. Even with a scientist's own research, about which he does his best to be entirely objective, he cannot keep his feelings out of it altogether. His feelings may even influence the observations he makes and the conclusions he reaches. If a scientist finds it difficult to be completely objective about his research, how can an ordinary person hope to be objective about things and

events that are important to him? The answer, of course, is that he is not, and cannot be.

Se we limp along, being both objective and subjective at the same time, even when the two views, or the effects of them on our lives, conflict with one anothur. We really live in two worlds at the same time. One world consists of "what we bump our heads against," the other world consists of "our feelings about what we bump our heads against."

LABORATORY EXPERIENCE F.1.a.

Poetry and Science

Introduction:

A poet's job is to create beauty, to use language as the material with which he works. However, he also deals with ideas. Sometimes these ideas are the same ones with which science deals. Do the poet and the scientist look at the same ideas in the same way? In this laboratory experience we will examine a few specific cases, and see how the scientist's approach differs from the poet's approach.

Materials and Equipment:

Collections of poems (anthologies)

Science books that deal with the same topics about which some of the poems are written

Collecting Data:

Read the following poem:

Each in His Own Tongue

by William Herbert Carruth

A fire-mist and a planet,
A crystal and a cell,
A jellyfish and a saurian,
And caves where the cave men dwell:
Then a sense of law and beauty
And a face turned from the clod---
Some call it Evolution
And others call it God.

What is the poet trying to say? Is he trying to tell what evolution is? Can you get a definition for evolution by reading the poem? Is he trying to tell how evolution has taken place? How much does he have to say about the process of evolution? How much would you know about evolution if this poem was your only source of information? Is the poet trying to express the beauty that he sees in evolution? If he is trying to express beauty in connection with evolution, does this interfere with his setting forth the facts of evolution?

Read about evolution in any standard high school biology textbook. What is the writer of the textbook trying to say? Is he trying to tell what evolution is? Can you get a definition for evolution by reading the book? Is he trying to tell how evolution has taken place? How much does he have to say about the process of evolution? To what extent does the beauty of evolution come through to you in reading the textbook? If the writer is trying to present the facts of evolution,does this make it impossible for him to express beauty?

Is the poet trying to show purpose in evolution? For example, is he trying to say that evolution has taken place in order that man could appear on the earth to fulfill part of a plan? Does the textbook writer, as a scientist, seem to think that evolution took place because of purpose in the universe? Because of the activity of a Creative Mind in the universe?

Are the poet and the scientist talking about the same things or about different things? Which point of view do you personally prefer? Why?

Now read this poem:

Trees

by Joyce Kilmer

I think that I shall never see
A poem lovely as a tree.

A tree whose hungry mouth is pressed
Against the earth's sweet flowing breast;

A tree that looks at God all day,
And lifts her leafy arms to pray;

A tree that may in summer wear
A next of robins in her hair,

Upon whose bosom snow has lain;
Who intimately lives with rain.

Poems are made by fools like me
But only God can make a tree.

Ask yourself the same kinds of questions that you did in connection with the first poem:

Is the poet trying to describe a tree? Is he trying to tell you how to recognize a tree when you see one? Why or why not? Is he trying to tell how a tree grows? How much would you know about trees if this poem were your only source of information? Is the poet trying to express the beauty that he sees in trees? If he is trying to do so, does it interfere with his setting forth facts about trees? Does a tree have anything that might reasonably be called a "mouth," "arms," "hair," "bosom?" Is the poet justified in using these terms? Why or why not?

Read about trees in any standard high school biology or botany textbook. What is the writer trying to say? Is he trying to describe a tree? To tell what are its parts? How it grows? To what extent does the beauty of trees come through to you in the scientist's writing?

Is the poet trying to say that he sees something beyond mere facts in his view of a tree? Is purpose implied in the poet's writing? In the writing of the scientist? What about the relationship of trees to a Creative Mind in the universe?

Are the poet and the scientist talking about the same things or about different things? Which point of view do you personally prefer? Why? Do you think that the scientist might be able to see the tree as the poet sees it, as well as in the way that he studies it? Do you think that the poet might be able to understand botany as well as write poems?

Finally, read this poem:

Jabberwocky

by Lewis Carroll

'Twas brillig, and the slithy toves
Did gyre and gimble in the wabe:
All mimsy were the borogoves
And the mome raths outgrabe.

"Beware the Jabberwock, my son!
The jaws that bite, the claws that catch!
Beware the Jubjub bird, and shun
The frumious Bandersnatch!"

He took his vorpal sword in hand:
Long time the manxome foe he sought---
So rested he by the Tumtum tree,
And stood awhile in thought.

And as in uffish thought he stood.
The Jabberwock, with eyes of flame,
Came whiffling through the tulgey wood,
And burbled as it came!

One, two! One, two! And through and through
The vorpal blade went snicker-snack!
He left it dead, and with its head
He went galumphing back.

"And hast thou slain the Jabberwock?
Come to my arms, my beamish boy!
O frabjous day! Callooh! Callay!
He chortled in his joy.

'Twas brillig, and the slithy toves
Did gyre and gimble in the wabe:
All mimsy were the borogoves,
And the mome raths outgrabe.

What is the poet trying to say? Is he trying to say anything? Is he trying to present any facts? Is he trying to present an idea? If so, what do you think it is? Is he trying to create beauty? Is he trying to express a feeling? A point of view? A "picture?" How does the poem make you feel? Does the poem bear any relationship to science? To science fiction? What is the relationship of science to science fiction?

Follow-Up:

Discuss the questions raised in connection with this experience in class and with members of your group. Is it necessary to arrive at any definite conclusions? Why or why not? If you do not arrive at any definite conclusions, has the experience had any value? If so, what value?

Find other poems which deal with topics or ideas which a poet and a scientist might look at differently. What aspects do the two views have in common? How are they different?

Make a poem, using the following formula:

First line: the name of something (a noun)
Second line: two words describing the noun (adjectives)
Third line: an action word (verb)
Fourth line: two words describing the action (adverbs)
Fifth line: any single word which is meaningful when added to the words in the first four lines

Example:

Cat
Soft, silky
Purrs
Softly, contentedly
Alone

Try to put as much beauty of thought and expression into your poem as you can. Do this several times and/or have several persons do it independently. Compare the different products. Can you decide which is the "best" one?

Try to make a poem following the same formula which embodies one or more scientific facts. Try to make it beautiful at the same time. Try this several times and try to decide on the "best" one.

What makes one word combination "beautiful" and another "less beautiful?"

LABORATORY EXPERIENCE F.1.b.

Music and Sound

Introduction:

What is the difference between noise and music? How does noise make you feel? Is music to you, noise to another person? Is there a difference in how different kinds of music affect you?

Materials and Equipment:

Noise-making devices such as whistles, clappers

Musical instruments

Pitch pipe or tuning forks

Collecting Data:

The scientist can determine the pitch of a sound. Use the pitch pipe or a set of tuning forks to determine the pitch of the sounds made by several devices. The pitch of a sound is determined by the wave length (frequency) of the vibrations. How many different ways can you find to change the pitch of a sound?

The scientist can also measure the intensity of a sound. Loudness of a sound depends on the intensity and the distance of the listener from the source. Loudness is measured in decibels. Intensity is determined by the size (amplitude) of the vibrations.

Rhythm is another characteristic of sounds; the "beat" is a common term. Make sounds —— - - -, —— - - -, —— - - -. Make other patterns of rhythm.

Now if you know the pitch, the loudness, and the rhythm of sounds you have scientifically analyzed the music. What is left out? Is there any "feeling" about it? How do you "feel" the difference between dance music and church music? Between country music and jazz? Between Beethoven and rock? Would it be possible to describe how you "feel" about any of these examples in terms of the scientists' characteristics of sound: pitch, loudness and rhythm? Do the pitch, loudness, and rhythm describe why some music makes you sad? Or why some music makes you feel happy? Does previous experience with certain sounds influence how you feel? Would your feelings affect your analysis of certain sounds? Find a piece of music written in a minor key. How does it make you feel? Is it the pitch, loudness, or rhythm, or something else that gives you that feeling?

Follow-Up:

What is the difference between the sound of a piano and of a violin? What are overtones? Can they be measured? Do they contribute to the "feeling" that the music produces in you? What is the difference between music and noise? May the "music" of one nation or culture be "noise" to another? Is your response to certain kinds of music a matter of education or habit? What about the music of primitive peoples?

LABORATORY EXPERIENCE F.1.c.

Art and Reality

Introduction:

What are the differences between a photograph and a painting or drawing of the same person? Of the same scene? How does your observation of a person or scene differ from either a painting or a drawing.

A scientist would carefully measure all of the dimensions, proportions, and relationships of the parts of the person or scene. He would describe the color or colors or even give the wavelength of each color or variation of color. In the end he would come up with a literal or even a mathematical description of the person or scene. How does a painting or drawing or your description differ from what a scientist does, other than that it is in less detail? Does a photograph differ in any way from the scientific description that we have imagined? May some photographs be closer to a scientific description than others? Why? How about an "artistic" photograph?

Materials and Equipment:

Drawing paper

Water colors

Drawing pencils

A book or guide for identification of trees (with pictures)

Photographs of trees

Children's pictures of trees

Copies of artists' pictures of trees

Copies of artists' paintings of animals

A small camera

Collecting Data:

Look at a tree. Determine what kind of tree it is from a book on identification of trees. Write down a description of your tree. Describe it as accurately and in as much detail as you can. Now look at a picture of this kind of tree in your tree book. Did you record anything in your description that does not show in the picture in the tree book? What? Is there anything in the picture that was not in your description? What? Is the picture in the book an artist's picture or drawing, or a photograph?

Take a photograph of your tree with a small camera, either in color or black and white. Does this picture differ from your description? How? Does it differ from the picture in the book? How?

Examine children's water color pictures of trees? Do they serve to describe trees? Can you tell what kinds of trees they are supposed to represent? Do they serve to get across ideas about trees? What ideas? Do they show how the children feel about trees?

Examine artists' paintings of trees. Do they serve to describe trees? Can you tell what kinds of trees they are supposed to represent? Do they serve to get across ideas about trees? What ideas? Do they show how the artists feel about trees? What feelings?

Try to paint pictures of trees yourself, using drawing paper and water colors. If you would prefer to do so, you can make black and white drawings. You may want to try this several times before you stop, and you may find that you surprise yourself how well you can do it. Many people have taken up art in this way.

Examine your best work. Have you described trees? Can you tell what kinds of trees you have painted or drawn? Can anyone else tell? Have you been able to get across any ideas about trees? What ideas? Any feelings about trees? What feelings?

Which is more real: a word description, or a photograph, or an artist's representation? What is reality? Are ideas real? Are feelings real? Are they as real as leaves or bark? Why or why not?

Follow-Up:

Examine artists' pictures and photographs of animals doing various things. Can you tell anything about what the animal is doing? Feeling? Thinking? Animals do things? Do they also feel? Think? State a basis for your beliefs?

LABORATORY EXPERIENCE F.1.d.

Study of Motion and Interpretive Motion

Introduction:

When you were in kindergarten you "walked like an elephant," "ran like the wind," "tiptoed like a fairy," and "trotted like a horse." You didn't ask why you could move or how you moved. You moved so you could be an elephant, the wind, or something else! You probably never thought about motion until a science teacher told you in a later grade about Sir Isaac Newton, and introduced you to the Laws of Motion that he discovered. Is there any relationship between the scientific Laws of Motion and your kindergarten play? Let us think about it!

Collecting Data:

In order to move anything a force must be exerted which is greater than the forces which are already acting upon it. These are inertia, gravity, and friction. What other forces might there be?

In order to exert a force there must be an energy source. What are some energy sources? When we think about force and motion in these terms we are dealing with pure science.

An automobile moves because the energy stored in the gasoline is released by an internal combustion engine. The engine converts the stored energy of the gasoline into mechanical energy which is then applied through a series of gears and wheels. The mechanical energy exerts a force great enough to overcome the opposing forces of gravity, friction, and inertia, and move the car.

Sir Isaac Newton in the 1600's discovered and stated what are now known as the Laws of Motion:

1. An object remains at rest or in uniform motion in a straight line unless it is acted upon by a force. (An object stands still or moves straight ahead unless something pushes or pulls it).

2. The acceleration which a force gives an object is directly proportional to the magnitude of the force, and inversely proportional to the mass of the object. (The harder you push or pull, the faster the object goes; the bigger the object is, the slower it moves with the same push or pull).

3. For every action there is an equal and opposite reaction. (For example, if you shoot a gun, it "kicks back" against your shoulder. The more powerful the shot, the harder the kick.)

How do these Laws of Motion apply to propeller-driven airplaines, jet airplaines, rocket-driven space ships? Can any of these devices do things like those you did in kindergarten? Why or why not?

How does the motion of living things differ from that of non-living things? How are they alike? Note that both depend on energy.

Motion of living things exhibits feelings. Can you tell when a dog's "feelings are hurt?" Can you tell when a dog or cat is angry even though it can't talk to you? When you "walk like an elephant," "trot like a horse" or "crawl like a fly" you are interpreting what you believe to be the behavior of the other living thing. Are you showing how you think it feels? Can you do this with the motions of non-living things? What about the motion of an automobile, an airplane, a space ship? Can you express this? Is there any feeling it it? (See the following Laboratory Experience F.1.e. "Science and Dramatics"for further exploration of possibilities of this kind).

What is dancing? How many different kinds of dancing are there? Do all kinds of dancing serve to express emotions? What emotions?

Can you describe dancing in terms of Newton's Laws of Motion. Choose a simple example of dancing and try to describe it in terms of Newton's Laws of Motion.

Follow-Up:

The native dances of the Indians, Polynesians, Latvians, and other peoples express feelings. Ballet dancing uses specific movements to tell a story that can be interpreted by the observer. Persons trained in modern dance may use movements to express deep feelings or tell a story. Find out all you can about primitive or other folk dances that express emotions or tell stories.

What is square dancing? Does it express feelings? Does it tell stories?

LABORATORY EXPERIENCE F.1.e.

Science and Dramatics

Introduction:

It isn't so much what you say as how you say it, and it isn't so much what you do as how you do it. When we say that we dramatize a situation, we mean that we put "feeling" into it. "Feeling" in this sense involves emotion. Drama is a form of art that is a way of telling a story by words and actions, which may involve emotion.

When we dramatize something, however, we also are trying to express it clearly, so that no one may have any doubt as to what we mean. Science involves expressing facts and ideas clearly, without any doubt as to our meaning. Can we dramatize situations in science? Or is this an entirely different use of the word "dramatize?" Is there any emotional content in science? Or must a person rid himself of all emotion in thinking about or talking about scientific situations?

As happens so frequently when we attempt to talk or write about something, we find that words don't always mean the same things under different circumstances. We will try, in this laboratory experience, to explore some aspects of dramatization in expressing emotions, and scientific facts and processes.

Materials and Equipment:

A lively imagination

Cultivation of an ability to put "feeling" into words and actions

Collecting Data:

First try to express emotions by dramatization. Use action, facial expression, and gestures, but no words to express the following emotions:

a. Anger
b. Surprise
c. Fear
d. Worry
e. Sympathy
f. Any others that you wish to try

Now do the same thing, adding words to your other means of expression. Limit yourself to not more than five words, however, in each case.

Do the same thing (first without words, then with words) working in pairs. In this case each student may use a maximum of five words.

In every case (without words, with words, alone and with another student) put as much feeling as you can into your dramatization. Try at the same time to get across a clear understanding of what you are trying to express.

Now try to express scientific facts and processes by dramatization.

Use a group of three students to show how the moon moves around the earth while the earth is moving around the sun. Read about this process, and get all the facts straight in your mind before you try to dramatize it. Discuss it with the class if you need to do so. Can you use the same method to show the movements of all the planets in relation to the sun and to one another? What about their moons?

Use a similar process to show the structure of (a) the hydrogen atom, (b) the helium atom, (c) the lithium atom, (d) the carbon atom, (e) the nitrogen atom, and (f) the oxygen atom. What are isotopes? Can you show isotopes of these atoms?

Photosynthesis is the process by which green plants use the energy of sunlight, in the presence of the green pigment chlorophyll to make food material in the form of simple sugars. A simple outline of this process is as follows:

Carbon dioxide (CO_2) + Water (H_2O) forms simple sugars ($C_6H_{12}O_6$) + Oxygen (O_2)

The chemical equation for photosynthesis, leaving out the complex details, is:

$$6CO_2 + 6H_2O \xrightarrow[\text{(Presence of chlorophyll)}]{\text{(Energy of sunlight)}} C_6H_{12}O_6 + 6O_2$$

Can you dramatize this process, using people to represent the atoms of carbon, hydrogen, and oxygen? How many people would you need to do this if you let one person represent each atom? Can you think of a way to tell the same story, using fewer people? How might you do this? How could you show the "energy of sunlight" and the "presence of chlorophyll?"

Do the dramatizations of the earth, moon, and sun, the structure of the atoms, and the chemical reaction of photosynthesis help you to understand these scientific facts and processes? How and why? Are these dramatizations related to models? How are they better or less good than models?

Were your dramatizations of emotions related to models? Can you make a model of an emotion? Did you do so? Why did you not need to read about and discuss the emotions before you tried to represent them? Would you have been able to do a better job dramatizing the emotions if you had read about them and discussed them?

How accurate were your representations of the scientific facts and processes? How accurate were your representations of the emotions? What part does accuracy play in regard to scientific facts and processes? How important is it? What part does accuracy play in regard to emotions? How important is it? To what extent are we dealing with the same kind of thing in the two cases? With different kinds of things?

Follow-Up:

To what extent does emotion enter into science? Was there any emotion involved in the landing of the astronauts on the moon? Was the moon landing dramatic? What made it so? What was the relationship of emotion to science in this case? Can you think of any other cases where there may be a relationship between emotion and science?

Is it possible to make a scientific study of emotions? How do you think it might be done? Can you be "scientific" about "feelings?"

Idea That a Scientist Is Limited By What He Believes About His World F.2.

Idea Bridge: A Scientist Is Never More Than Partly Free

A scientist is never free to do all the things that he really is able to do. He is always limited to some extent by the nature of the society in which he is working. Scientists in communist countries find that the kinds of things that they can do are limited by basic communist beliefs. For example, Communism assumes that all living things, including man, are entirely what their environment makes them. This is a belief that Karl Marx, the founder of Communism, set forth more than 100 years ago. Communist biologists cannot believe in or investigate the role of genes in heredity. Genetics, the basic science of heredity, is therefore not a communist science.

Scientists in the "free world" are not really free either. For example, they are not free to carry out experiments on human beings that end in death or even produce pain. They cannot do these things even on prisoners who are condemned to die anyway. They can only work with volunteers in cases where pain or the danger of death are involved. Scientists in the "free world" are limited by the Christian belief in the existence and value of individual human souls. This is true even in the case of individual scientists who themselves do not believe in Christianity or in the existence of souls. This is because these beliefs are built into the foundation of our western culture.

Communist scientists cannot study heredity because they do not believe in its existence. "Free World" scientists cannot experiment on human beings because they believe that to do so is "wrong." Scientists are never free to do all the things that they know how to do, and that they could do if they were really free.

LABORATORY EXPERIENCE F.2.a.

A World of Magic

Introduction:

It is always interesting to try to answer the question: "What would have happened if---?" Sometimes we can make a fair guess, if the event in question is something that happened in our own lives---if we had or had not met a particular person, or gone to a particular place or done a particular thing. Sometimes also we can think what might have happened if a particular event in history had turned out differently from the way it did---if a particular person had not been killed, or if a particular battle had been won instead of lost. How different would our present world have been if President John F. Kennedy had not been assassinated in 1963? What would have happened if the South had won the Battle of Gettysburg in the American Civil War instead of the North?

Science fiction writers have sometimes used the idea of "alternative worlds" to follow up such questions. In doing this they have pictured worlds that would have (or might have) resulted from such "what ifs." In this laboratory experience we will look at a possible "what if" world, and in so doing see what might happen to a scientist if he were in a different social environment.

Materials and Equipment:

Tolerance to read (or hear) the story through

Objectivity to consider it and its implications

Imagination to picture the resulting situation.

Collecting Data:

A young man who is working on a doctor's degree in engineering physics is driving alone along a crowded highway. Another car forces him off the road. His car is wrecked and he is knocked unconscious, but is otherwise not seriously injured. When he regains consciousness he discovers that he is lying beside a broad trail winding through partially settled country. The highway and the wrecked car and the traffic are nowhere to be seen. Instead, he apparently had been traveling in a horse-drawn cart. The horse must have become frightened at something, run off the road and thrown him out of the cart against a tree. Horse and wrecked cart are standing nearby. He has been thrown into an alternative world by the shock of his accident.

Two men come along and offer to help him. He finds that their language differs only slightly from his own. They are kind to him, take care of his horse and cart, and take him with them into the nearest town. He of course, does not realize yet that he is in an alternative world, but he quickly discovers that this is not the world he knows, even though the day of the week, the month, the year and the season are the same ones that he left.

He is in the same part of the world where he has been,although it has apparently developed differently following some event in the past. History here has taken a different turn from the history that he knows. He must try to live in this world and adjust to it, since there is no way to get back to his own. What is this world like that he has "fallen into?" How did it get to be this way--- so different from the world he left? Read on!

In the 900's (Tenth Century), Western Europe was dominated by the medieval church. The only view of the world that was accepted was that which was presented by medieval Christianity. All people were automatically members of the church. Even kings were subject to it, and had to do what it told them. Science in the modern sense was unknown.

Science did not have a beginning for another 200 years. Ultimately it grew out of the monastery schools and universities which were sponsored by the church. The freedom of scientists to do research, however, and to try to understand the natural world through observation and experimentation, developed only gradually from this beginning.

The only challenge to the authority of the church in the tenth century was that of the magicians, the warlocks and witches. These were real people with a real set of beliefs who operated outside the church. Magic was a kind of "science." Its followers and those who practiced it believed in it as completely as our modern world believes in science. They believed that they could really "do things" with it as we can with science. In many cases the witches and warlocks gave their lives for their beliefs. The church generally burned them at the stake when they could catch them.

There were definite "laws" of magic which its practitioners followed, just as scientists now follow scientific laws. For example, if you wished to bring about the suffering or death of an enemy, you made a little wax image of him. It was more effective if you could put in it a hair or nail clipping or something else from his body. Then you gave the image his name, and proceeded to stick pins in it, or melt it in the fire, or otherwise mistreat it. Of course you had to say the appropriate "spells" or formulas while you did so. Witches and warlocks believed that your enemy would suffer as his image suffered.

This law of similarity went farther. There was "white" (helpful) magic as well as "black" (harmful) magic. If a man were ill you could treat his illness with water or some other liquid in which a root shaped like a man had been boiled; or you could treat him with powder from burning such a root. This again, however, must be accompanied by appropriate "spells." You could summon a spirit with proper "spells" and keep it imprisoned in a pentagon (five-sided figure). You could keep demons out of a house by placing a sign of three interlocking triangles over the door.

The magicians believed that the laws of magic worked, just as we believe that our scientific laws work. The interesting thing is that the church also believed that the laws of magic worked. That is why they tried to stamp out the magicians. They were afraid of them.

The church won in the end, and out of it, in succeeding centuries, modern science grew. Even with science, the church had its difficulties later on.

What if the church had not won? In the world into which the young engineer was thrown by his highway accident, the church did not win. Instead, the magi- ns won. The world that resulted was different. Magic itself had become a kind

of religion. The church continued to exist but played a much smaller part in this world and existed mostly "underground."

In 978 A.D. a very able young man, named Martinus Gerardus, was the leader of the magicians in Southern Germany. He was a noted warlock, and had a strong following. In the history that led to our world, he was captured by the agents of the church, and was burned at the stake. In the history that led to the alternative world into which the young engineer was thrown, he was not burned to death. Instead he escaped, and ultimately united all of the magicians in Germany, defied the church and overcame its power. His influence spread all over Western Europe. He became a sort of "pope" to the religion of magic, and his successors continued as absolute rulers right down to the late 1900's (20th century).

Our young engineer was astonished at the world into which he had been thrown, particularly at its scientific backwardness and lack of development. Nevertheless he learned its ways and found its people friendly. Each town and city had two rulers. One of these was a kind of chief or overlord. The other was a magician. The engineer found the overlord friendly, but the magician was suspicious. He recognized in the engineer a kind of rival magician, because it quickly became apparent that the engineer could do some simple things that the magician thought of as belonging to the world of magic. Of course, in the absence of modern technology, the things the engineer could do were very limited. He set up a workshop or laboratory, however, made a simple electrical battery, produced static electricity, made simple chemical indicators change color, and did several other things that belong to science.

The engineer was seized and imprisoned. The overlord interceded for him, but the magicians' court sentenced him to be burned at the stake as a heretic (unbeliever) whose magic was of a different sort, and therefore was dangerous and posed a threat to their world.

Finally, the overlord, with whose daughter the young engineer had fallen in love, secretly enabled him to escape. He fled to a mountainous part of the country, where the Christian church maintained several "underground" cells. The monks there sheltered him.

Think of the following questions in relation to this story:

1. Some parts of the above story are factual, some parts are partly factual and partly fictional, and some are purely fictional. What parts are true? Partly true? Entirely fictional?

2. In the alternative world the young scientist was not "free" to practice his science. What was it that kept him from being "free?"

3. Would a magician be "free" in our society to practice his magic? What would keep him from being "free?" The same thing, or something different?

4. To the young scientist, the world of the 1900's ruled over by the magicians was a "backward" world. Do you think that our world would seem like a "backward" world to a magician similarly thrown into it? Why, or why not?

Follow-Up:

It is obvious from reading the story that forms the basis for this experience that it is left unfinished. Finish it. How many different ways can you think of doing this?

LABORATORY EXPERIENCE F.2.b.

Could We Produce a Superior Strain of Man?

Introduction:

We have produced superior strains of dairy cows, beef cattle, hogs, sheep, chickens, turkeys, racehorses, dogs and cats, and various agricultural crops. We have done this by selection and combination of individuals containing desirable hereditary characteristics. Other than personal, moral or other subjective limitations, there is no scientific reason why we should not be able to produce a superior strain of humans, containing those characteristics which we consider desirable: high general intelligence, superior special abilities which have been shown to have a hereditary basis (musical, mathematical, artistic, mechanical). These could be combined with physical superiority, inherited resistance to certain diseases and any other desirable traits. All of these things have been done with special strains of domestic animals or plants. Of course these traits all interact with environment in their expression, but they have a genetic basis.

There have been a few brief attempts to produce superior strains of humans. Frederick the Great attempted to obtain tall soldiers for his army. Adolph Hitler pursued a concept of "race" which had no scientific basis. All such attempts lasted for only a few years; in no case for even one human generation.

Actually, man's peculiar genius in the matter of evolutionary survival has been his extreme variability. Any species is more likely to survive from an evolutionary standpoint if it is more variable. The less variable it is, the less likely it is to survive. This is because a widely varying species is more likely to contain some variants which will be able to meet any possible environmental challenge. This characteristic has enabled man to spread over all habitats on earth and even into outer space. Add to man's extreme variability his invention and evolution of clothing and other devices. These serve to extend his variability.

An "improved" variety (of domestic animals or plants or of man himself) is a specialized variety. A specialized variety becomes so by narrowing its range of variability. This is an inevitable result of any specialization. In the past history of life on earth, when any species or other group has become specialized it has been on the road to extinction if it faces a changed or changing environment.

One of the reasons that man has not been able to develop improved varieties of his own species is that he doesn't live long enough to do so. In the case of his domestic animals and plants he is able within his life time to work with several generations of these species. In his own case he is able at most to see parts of only three generations: his own and the one preceeding and the one following his. The same thing is true of elephants. Although, the elephant has been domesticated for a very long time, the fact that its life span (about 200 years) is longer than that of man has made it impossible for man to develop improved varieties of elephants.

Sir H. Rider Haggard, an English writer of the past century, wrote a story called "She," in which he told of a woman who ruled an undiscovered semi-civilized nation in Africa. She had found a way to keep her youth and beauty

and prevent aging and death. She had lived for years. During this time she had produced a race of deaf mute servants by selective breeding. She could do this not only because she was an absolute ruler, with power of life and death over her subjects, but also because she lived longer than they did. She had lived through approximately 75-100 human generations.

If it were possible to eliminate legal, moral and personal objections to the selective breeding of humans, is there any way that the difficulty imposed by the length of the human life cycle could be overcome? Might it be possible to eliminate all of these objections and difficulties? If this could be done could a superior race of humans, a real "Homo superior," be produced? The following science fictional situation explores this possibility.

Materials and Equipment:

Tolerance to read (or hear) the story through

Objectivity to consider it and its implications

Imagination to try to picture the resulting situation

Collecting Data:

It is now the month of October during the school year 2083-84. The world has been at peace for a hundred years. In 1982, a century ago, the Third World War appeared inevitable. Three giant nations, the United States, Russia, and China, all possessed nuclear bombs and the missiles to deliver them to their targets. Which two powers would be allied against the third? This was what the world asked. Then the Russians discovered how to control the energy of the H-bomb (nuclear fusion energy) making it available for peaceful purposes instead of using it to make war. To the surprise of the other two nations and the rest of the world, they announced that they were giving it to mankind without any reservations.

For the first time in history, man had available an almost unlimited supply of energy. There was so much of it that it had to be inexpensive. There was no longer anything to fight about. The United Nations, which had floundered helplessly since its foundation in the late 1940's, became a workable reality. Furthermore, mankind became wealthy beyond anyone's wildest dreams.

On this day, your class is being visited by a person that you have not seen before. He is a representative of the International Foundation for the Improvement of Man. This is what he tells you:

"We are now at last able to take the steps necessary to produce a superior race of man, a true Homo superior. We know that this can be done, because, after all, man is an animal. His biology, and in particular his genetics, are much like those of other animals. Long ago he learned how to produce superior races of domestic animals, mainly by selection and the isolation and combination of desirable hereditary characteristics. Now man is in a position to do the same thing with his own species. Of course this must be kept on a completely voluntary basis. Anyone who enters the experiment must do so by his or her own choice. Anyone must be free to leave the experiment at any-time he or she chooses to do so."

"The chief difficulty is time. The creation of superior races of domestic animals requires time in the range of 100 years, or sometimes less, depending on the length of the animals' life cycle. Man lives much longer than most of his domestic animals. He may be able in a single lifetime, to see 10-15 generations of domestic animals born, mature and reproduce, even in the case of the longer-lived kinds, like cattle and horses. Man, on the other hand, only passes through about 3-4 generations per century."

"A person wishing to supervise a program looking toward developing an improved kind of man would need to live for some hundreds of years in order to see enough human generations to observe the results of his experiment. As it is, any one person is able to see only his own generation, and the end of the generation preceding his own, and the beginning of the next one beyond his."

"What is needed is a deathless corporation or foundation, set up to oversee the experiment, and to operate for some thousands of years. This requires two things: (1) assured world peace, and (2) a great deal of money. Fortunately, now, the United Nations can supply both. Last year (2082) the United Nations set up an organization called The International Foundation for the Improvement of Man. It is designed to run for 5000 years, and is funded for a start at one trillion dollars. The funding, however, is open-ended. More money will be supplied as necessary."

"A number of people like myself are now traveling over the world talking to students and other groups of young people. We are presenting you with an opportunity. We are looking for volunteers who are willing to tryout for membership in the Foundation. If you volunteer, we will administer the tests, physical, mental and emotional. We have reason to believe that possibly 10 percent of those who volunteer will pass the tests, and be admitted to the Foundation."

"Once you are in, the Foundation will supply all of your physical needs and will open all avenues to you for educational opportunities (if you wish them). You may go to school, travel, work at what you like and as you desire to. You will probably want to live in one of the colonies set up by the Foundation. Here you will be with other Foundation members. You do not have to do this, however. You may live anywhere you wish. Furthermore, you are free to resign your membership and leave the Foundation at anytime you wish. Such resignation, however, is permanent. If you leave you could not be reinstated at a later time."

"Your children, when they reach your age, will be given the same opportunity that you have had. They do not have to try out for the Foundation, but if they wish to they can do so on the same basis that you did. They can take the tests, and if they pass them they can become Foundation members. Like yourselves, they will be free to leave the Foundation at any later time if they wish. The same will be true for their children, and their children's children, and so on for 5000 years, or approximately 175 human generations."

"We believe that in this way, with the cooperation of you and your descendants, we can produce Homo superior. There is only one thing that you have to do. As a Foundation member, you must marry the person whom we match you with."

"How many of you would be willing to volunteer to take the tests?"

Follow-Up:

If it were set up in this way, the experiment would work. A superior race of man would be produced. The same kind of thing could be done with man that has been done with domestic animals.

Would you be willing to be a part of this experiment if it were possible today? Why or why not?

What characteristics do you possess that you think would be a positive contribution to Homo superior? Do you have any characteristics that should not be characteristics of Homo superior?

Even though the experiment would work it would ultimately be a failure. Why?

Look up the history of the development of improved strains or breeds of domestic animals and plants. What part is played by selection, inbreeding, and hybridization in the development of improved strains of domestic animals and plants? What is hybrid corn and how is it produced?

LABORATORY EXPERIENCE F.2.c.

Three Score and Ten

Introduction:

Genes are the determiners of heredity. They are located in rod-like structures called chromosomes in the nuclei of the germ cells that give rise to new individuals. All genes interact with the environment to produce traits. They cannot produce traits by themselves. Neither can the environment produce traits alone. A gene must have an environment to work in. The environment must have a genetic basis to work on.

Most genes produce normal traits---determining our height, skin color, eye color, hair color and whether it is curly, wavy or straight, body build, general mental ability, and various special abilities (such as musical, mathematical, artistic, mechanical) all in cooperation with the environment. Some genes, however, produce abnormal traits, such as predisposition to diseases, certain deformities, or specific abnormal conditions, such as hemophilia (bleeder's disease) and color blindness.

Lethal genes are genes that kill. Some of them operate before birth. Such children are born dead. Others operate at various periods throughout life. All genes have a definite time as well as a definite place of expression. For example, genes for eye color operate early in life. Lethal genes are no exception to this. A gene that predisposes a person to the development of a stomach cancer in the seventh decade of life, or to the development of a respiratory weakness that may interact with the environment to produce pneumonia or tuberculosis in adolescence, is no less lethal than one which prevents normal development of the heart structure in the second month of embryonic life, if a certain trace element is lacking in the mother's food, and kills before birth. All of them kill if they receive cooperation from the environment.

Nevertheless there are some genes that are "more lethal" than others. There are some that require very little environmental interaction, and some that require much. The gene for faulty development of the heart structure may require little, as is probably true of many that operate during embryonic life. Younger mothers apparently furnish a better pre-natal environment than older mothers. Genes that operate after birth takes place do so in a much more complex environment, and lethals that operate after birth may require a greater degree of environmental cooperation to be fatal.

A person who has hemophilia (bleeder's disease) dies of it only when the environment, in the form of a severe injury when the bleeding cannot be stopped, interacts with the inherited gene. Good diet and good environment generally can prevent the expression of many partial lethals. Modern medicine works this way as a part of the environment. Antibiotics have saved the lives of many persons who were predisposed to pneumonia. Insulin has saved the lives of those who would have died of diabetes. Survery and X-rays have prevented the fatal expression of genes that pre-conditioned the development of cancer.

Even under wholly natural conditions, partial or borderline lethals may not develop. Cancer appears to result in many cases where an inherited tendency interacts with an appropriate type of environmental triggering. The development of an inherited tendency to diabetes is related to diet. An inherited respiratory weakness may be expressed when it interacts with some environmental provocation such as loss of sleep, general fatigue, exposure, or poor diet.

We are all full of partial lethals. It is probable that every chromosome has them thickly distributed throughout its length, waiting only for the environment to trigger their expression. Lethals and partial lethals constitute the basic mechanism that accounts for the basic mechanical imperfection of our physical bodies---the fact that they are not the marvelously perfect living machines that we would like to think they are. They are only good enough to "get by" for long enough to reproduce to a sufficient extent so that the hereditary strains that they contain will not be lost to the species. Those that are not that good die early and do not reproduce at all, or do so only to a limited extent. Perfection is a man-made concept. It has no place in nature.

It is safe to say that unless we die in an accident, or die in a war, or commit suicide, or are executed, each of us will die some day due to the interaction of some lethal gene with our environment. Modern medicine furnishes us with "crutches" of one sort or another, which enable us to limp across the weak spots in our life cycle. It saves us from the effects of one lethal, only to leave us exposed to others later on. The person who is saved from death from a respiratory disease in childhood, may live only to die from heart disease in his old age, being laid low at last by a lethal with which medical science has not yet learned to cope. However, we must remember that medical science is discovering and learning to use new "crutches" all the time.

Materials and Equipment:

Tolerance to read (or hear) the story through

Objectivity to consider it and its implications

Imagination to try to picture the resulting situation

Collecting Data:

Let us imagine a specific case. A girl born in the middle 1930's would have been only a small child in 1937 when the first antibiotic drug, sulfanilamide, was first used to combat the cocci (bacteria) that cause pneumonia. Let us follow such a girl through her life. Early deaths from pneumonia "ran in her family." She carried a respiratory weakness which, in conjunction with the presence of pneumococci in her environment and possibly other environmental factors, caused her to develop pneumonia in the winter of 1937. She had a serious case. Pneumonia at that time was frequently fatal. Her hereditary weakness was a partial lethal.

She would have died except that the family physician was a reader of current medical literature and kept up with the latest developments in his field. He had read of the new sulfa treatment. He was a friend of the

family, in whom they had great confidence. He obtained some of the drug from a hospital in the city, and got her parents' consent to try it. The effects appeared almost miraculous, as such cases did in those early days of chemical treatment of disease. The child's fever disappeared in a matter of hours and she was well in a few days. Medical science had furnished her a "crutch" to "limp over" a weak spot in her life cycle. Had it not been so she would have died.

The little girl grew up. She was not a strong child, but with good food, good home environment, plenty of rest and generally good care on the part of her parents, she escaped further serious illness. She finished high school and went away to the university. On the occasion of her first Christmas vacation she went home, and in the enthusiasm of seeing all her friends who were home also, and particularly the boy she loved, she stayed out too late too many nights, lost too much sleep, and finally following a hilarious New Year's Eve party, she took a deep cold which again allowed the ever present pneumococci to take hold in her lungs. She developed pneumonia again. This time, however, there were, in addition to the sulfa drugs which had saved her before, penicillin and other antibiotics effective for pneumonia. Her recovery was quick and complete. Although only a few days of vacation were left, she managed to return to school on time. Once again she had "limped across" a weak spot in her life cycle by means of a "crutch" that medical science could offer. Once again, under natural conditions she would have died.

After this, she had learned of her weakness and was more careful. She knew that in order to stay healthy there were certain things that she should not do. She graduated from college, married and raised two children, a girl and a boy. She and her husband were reasonably prosperous, so that she was able to maintain a good environment for herself and her family, and to have adequate medical care when she needed it. However, as she grew older she became stronger. (Middle-aged people are generally more resistant to infectious disease than young people). She had no more serious illness.

Finally, in her middle fifties (in the middle 1980's) another lethal gene caught up with her. She developed a breast cancer. Actually, as it turned out, it was not too serious. The cancer was diagnosed in its early stages. Surgery, with X-ray treatments following the operation, successfully destroyed the cancer. Our heroine had "limped over" one more weak spot in her life cycle with the aid of "crutches" furnished by modern medicine. Once more, however, she would have died in the normal course of nature.

During the following years there was no further trouble. Her respiratory weakness was now far in the past, and the cancer-producing tendency was operative only during the decade of her fifties. She was a relatively healthy old lady. Her daughter and son had married long since, and her grandchildren had grown up. Old age came on normally, but it left her with ample, though of course slowly waning strength. Now her children were becoming elderly people and there were great-grandchildren.

Finally, at the age of 92, in the decade of the 2020's there came the occasion of the wedding of her youngest granddaughter, a child born to her son and his wife late in their reproductive life. It was a great affair. The family arranged for the old lady to fly from Chicago, where she lived in a nursing home, to California to attend it. At the reception following the

wedding she ate much more than she normally did, and also drank a glass of champagne. This, along with the rest of the excitement was too much for her old heart and her hardened arteries. That night in her sleep she died of a coronary thombosis, a blockage of one of the larger vessels that feed the heart muscle. At last she had come to the point in her life cycle when a lethal was expressed which there was no means of circumventing. This was a weak spot for which there was no available "crutch" to enable her to "limp across" it.

Medical science, however, is constantly developing more and better "crutches." The next century will probably see the process carried much farther than even ours has done. So we can add another chapter to our story.

If the old lady had been born a century later, in the 2030's, her life history would have ended quite differently. In 2029, a medical researcher working for the Rockefeller Foundation developed a synthetic drug of relatively simple structure which could be produced inexpensively. This drug, when taken in small quantities by an individual with his food, prevented the formation in the blood of cholesterol, the substance which is responsible for the progressive hardening of the arteries with increasing age. Thus another "crutch" was added to medicine's growing collection, and the average human life span was correspondingly lengthened.

Just as the average life expectancy of a child at birth advanced from about 35 years in the 1920's to about 70 in the 1970's, with the development of antibiotics and other new types of treatment, so now it advanced still farther. With the arteries remaining flexible and "young," and the circulation to the brain and other body areas not diminishing with advancing age, the general process of aging, which depends largely on the aging of the circulatory system, was greatly slowed. Not only was the life span lengthened, old age was postponed. A man or woman of 70 felt and looked no older than a person of 40 had done a century before. At 90 a person seemed no older than we think of people normally being in their 50's. Old age came finally, but only with the aging of other body systems, and at a much slower pace. Finally, death from old age occurred normally at somewhere around 140-150 years.

By the 2040's the use of this age-delaying drug, which had been found to be completely harmless, and without any other physiological effect, had come to be as commonly accepted as is the use of iodized salt to prevent the development of goiter in our day. It was mixed with seasoning, added to bread, and placed in city water supplies. Everyone used it, just as a matter of course. A few radical religious groups objected to it at first, saying that God had never intended that people should live beyond the "three score and ten" (70) mentioned in the Bible, but their objection was short-lived. After all no one wanted to grow old and die if they could help it.

Of course the maximum effectiveness of the drug was with children who began to take it in their early years. It only served to stop the artery-hardening process. It did not in any sense "turn back the clock." If our old lady who died of circulatory breakdown at 92 had been born in the 2030's she would have lived to the ripe old age of 142, and would have died in the decade of the 2170's from the action of a lethal gene causing a breakdown of kidney function, a condition which even the advanced medical science of that day had found no "crutch" to help her circumvent.

Think about the following problems that are presented by this story:

1. What do you think of the general idea that all traits are necessarily due to the interaction of heredity and environment? Can you think of any traits that are <u>entirely</u> due to heredity, or <u>entirely</u> to environment?

2. What do you think of the idea that <u>all natural death</u> is a result of lethal genes interacting with environment?

3. What do you think about the role of medical science in relation to the growing population problem?

4. What do you think about the responsibility of medical science in keeping the genetically "unfit" alive and reproducing?

5. What do you think about the development of medical science in the future? Can medicine ever really <u>conquer</u> disease? Would it be a good thing if we could eliminate disease and death entirely? Why or why not?

6. Would you want to live to be 142 years old if you could? If everybody else was doing so? Why or why not?

<u>Follow-Up</u>:

What are some of the specific medical advances that are "making the news" in our time? What advances are distinct possibilities or probabilities for the near future? What about the possibilities of "genetical engineering," the substitution of normal genes for lethal genes in human chromosomes? Would it be a good thing if we could do this? Why or why not? If you were about to die of heart disease, would you accept a heart transplant? Why or why not?

LABORATORY EXPERIENCE F.2.d.

If We Could Go Back

Introduction:

In A.D. 1348 Western Europe was invaded by the common brown rat. This species replaced a black species of rat and drove them out. After this time the black rat was found only associated with waterfront and wharf locations. The brown rat became the common species associated with towns and cities and human dwellings. In general, the brown rat lives in closer association with man under unsanitary conditions than does the black rat.

Both species of rats are parasitized by fleas which also bite man. The fleas carry the disease bubonic plague which can attack both rats and humans. This disease is much more likely to be fatal to humans, however, than it is to rats. Rats, therefore, constitute reservoirs of plague from which human epidemics of it can and do originate.

The brown rats came into Europe from the East. They, and the bubonic plague they carry, had been common in India and some other Asiatic countries from early times. The human population in these countries had developed some resistance to plague through long exposure to it. (Note: The less resistant strains of humans had been eliminated by natural selection. They had died off and left few or no descendants.)

Since the black rats of Western Europe had not lived in close association with man, their fleas had generally not bitten humans, and plague was not known in Western Europe as a human disease before the 1300's. Therefore the human population in Western Europe had not had an opportunity to develop any resistance to plague. When the brown rats came in and lived in close association with humans, under the unsanitary conditions of medieval Europe, their fleas bit humans and transmitted the plague to them. Since the humans had little resistance plague became epidemic. Under epidemic conditions the disease can be transmitted from person to person by moisture droplets from the respiratory system, like a cold. This is called pneumonic plague rather than bubonic plague (which affects the lymph glands). In this particular historic case the plague was called the Black Death.

The Black Death swept through Western Europe in 1348 and the years immediately following. It killed up to half the population. In doing this it changed the whole pattern of European civilization. It became impossible to keep the people bound to the land as they had been under the feudal system of the Middle Ages. The system of serfdom under which the people had been bound to the land and held down by the nobility gave way to one of greater freedom. People went to the towns and found work there. Trade and commerce increased and cities grew. Art and literature and learning flourished. This new wave of human activity is called in history the Renaissance (rebirth). It was the beginning of modern civilization. Without the Black Death the world as we know it today probably would never have been. What would have been now in its place we have no way of knowing.

Modern medicine has a vaccine which can easily give people immunity to plague. People who travel to certain countries must be vaccinated against plague before they can get a visa to travel there. If this vaccine had been known to medical science in the 1300's the Black Death could have been prevented.

Materials and Equipment:

Tolerance to read or hear the following story through

Objectivity to consider it and its implications

Imagination to try to picture the resulting situation

Collecting Data:

An Englishman named Perkins in 1997 discovered the Principle of Reverse Entropy. A practical application of this principle led to the development of time travel in the early years of the 21st century. At first the "voyages" in time were for only short distances. It was found to be impossible to travel very far forward in time. This was because a time traveler going into the future very quickly arrived at a potential "decision point." At each of these points a choice is made. When we come to one of these points we go down one "road" or the other. Since there is no way of telling beforehand which "road" the future will take, the time traveler cannot go forward in time beyond this point.

It was found to be quite easy, however, to travel backward in time. This was a "road" that had been traveled. All that was necessary was to retrace it. Historical research now became possible in a way that historians of earlier centuries could only dream of. Students of ancient history could go back and see the battles of the American Civil War, or those that were fought between Rome and Carthage, or between the Athenians and the Persians.

Furthermore, it appeared to be possible sometimes by going back beyond a decision point---to an earlier time before a particular decision had been made, to influence or change the decision, so that an alternative "road" was taken instead of the one which led to the present world that we know.

Because of the tremendous possibilities that were involved, time travel came to be rigidly controlled. A committee of scientists and historians, appointed by an international agency controlled by the world's three great super powers: Soviet Russia, China and the United States, made decisions as to who could travel in time, where they could go, and what they could do.

A proposal came up in 2070 for consideration by the Time Control Committee to send a medical expedition back to the early decades of the 1300's to immunize the population of Western Europe against bubonic plague. Imagine yourself a member of the Time Control Committee. What position would you take in regard to sending this expedition? Why? Is it possible that you might never have been born if such an expedition were successful?

Why? Would this affect your decision in view of the thousands of lines that would be saved by the expedition?

Follow-Up:

Granting that you could travel backward in time and change the course of history in particular cases, what events would you try to influence or change? Why? What do you think might have happened if you could succeed in changing these particular events? Why? Are there any events in your own life that you would go back and change if you could?

LABORATORY EXPERIENCE F.2.e.

The Twenty-Sixth Century

Introduction:

It is possible to imagine a society in which technology (mechanical inventions, the applications of science) forms the basis of civilization, while science in terms of research and discovery is not permitted. Such a society could develop from the one that we have now. It could do so if people became afraid of scientific discovery. The result could be a political dictatorship which would forbid research.

Materials and Equipment:

Tolerance to hear or read this story through

Objectivity to consider it and its implications

Imagination to try to picture the resulting situation

Collecting Data:

Time travel to the past was developed in the early part of the 21st century. The only workable method of time travel to the future that could be discovered, however, was to place a person in a state of suspended animation (a kind of long sleep) and wake him up at some future time.

This was tried for short periods of a day, a week, a month, a year. In all cases the persons who had been put to sleep woke up in a healthy condition, none the worse for the experience. Medical tests showed that they did not grow old while they slept, and they were free from disease.

Finally, it was decided to put a volunteer to sleep and wake him up in the 2500's---500 years later. A pyramid was built of indestructible material in the Ozark Mountains of Arkansas. A young scientist volunteered for the experience. He was placed in suspended animation and set to wake up in 2544 A.D. The interior of the pyramid was fixed so that the air would be renewed and the temperature would be regulated. When he woke up he could open it from the inside. A record of the experience was engraved on a stainless steel plate which was fastened on the outside of the door, together with the day when he would emerge.

On the day of his emergence, May 3, 2544, a delegation from the world government was on hand to welcome him. He opened the door about 10:00 A.M., and walked out. The daughter of the world dictator stepped up to him and spoke to him in a language descended from the English spoken 500 years before. (Can you find out how the English of today differs from the English of 500 years ago?) He could understand her, but it was difficult. She introduced the other members of the delegation, and took him by helicopter to the seat of the world government in St. Louis.

All of the country in the valleys of the Mississippi and Missouri Rivers was filled with houses. All farms had disappeared. The helicopter flew low and he could see the people on the streets. In some places they were

coming in and out of factories and other places of work. All but a few of them were a kind of gray uniform. Much of the work that they were doing involved the tending of complex machines which he did not recognize. The few who were not in gray uniforms wore distinctive clothing of various colors: red, green, yellow, blue.

He asked the girl what was the meaning of all this. She told him that those who were wearing gray were the slaves. Those wearing colors were the various grades of officers, foremen, and directors. The work that all of these people were doing was producing the various synthetic products that the civilization needed. These included synthetic food, synthetic fabrics for making clothing, plastics to take the place of wood and metal, synthetic medicines to cure illness. She told him that the energy to produce these things came from nuclear fusion (the tamed energy of the present-day H-bomb).

He had not been particularly surprised to see how the growth of human population had filled all available living space with people. He remembered that there had been much talk about the population problem in his own time. He asked the girl, however, about the slaves. She told him that with so many people in the world, it would not be possible to feed them and produce the things they needed without slavery.

She asked him what he had done in the world of 500 years before. He told her that he was a research scientist. She asked him what research was. He told her that research was a means of learning about the natural world and discovering new truth. She told him that there was no longer any need to learn more about the natural world---they already knew all that they needed to know---there weren't any new truths. "Truth is truth, and that's all there is to it." He asked her what he might do in her world, since he had no way of going back to his own. She told him that he would be put through a series of tests, and assigned to a job that would be suitable for his abilities. If he or any other person objected to his assigned role, "mental reconditioning" would change him because the tasks could not be changed.

When they arrived in St. Louis he was taken to the office of the girl's father, the world dictator. He found the dictator to be similar to any political leader or business executive of his own day, but he was told very firmly, that in this world everyone did what he was told to do. Of course there were tests that everyone took, and it was on the basis of these tests that work assignments were made. Again he asked about scientific research, and he was told that society already knew enough about the natural world---that there were no new truths anyway---and that if there were they would be dangerous because they would upset the balance of society and might destroy it.

What do you think happened to the young scientist? Finish the story. How many different ways can you think of that it might end? Do you think a civilization like this could develop out of our own? Why or why not?

Follow-Up:

Do you think we can do anything now to determine what the world will be like 500 years from now? Do you think it is possible for society to destroy science? Do you think it is possible that science may destroy itself? Is science really "good" for society? Could society get along without it? Might it be "better off" without it?

Idea That a Scientist is Limited by His Own Limited Mind F.3.

Idea-Bridge: A Finite Mind in Infinity

A scientist is limited by his own mind---the mind of the unique form of life called MAN, the finite (limited) mind of a finite (limited) creature.

A person cannot conceive of anything that is without a beginning and without an end. Even a scientist can't conceive of a distance that has no beginning and no ending. He cannot conceive of the comparative size of an electron and the Milky Way Galaxy. He can make models, but unanswerable questions are inevitable.

He cannot conceive of "no beginning" and "no end" to time, although he talks about "eternity." He can make models of events in time, but always there are questions that can't be answered.

He can use his senses and all of the extensions of his senses that have been invented. He can conceive of new inventions that he has never seen. He can use models that have been made. He can devise new models. He can hope to be able to go on learning more and more about the physical world, and the physical universe of which it is a part, until ultimately he would know all there is to know. He realizes very well, however, that he will never be able to reach this goal. He can only hope, and keep on trying. Always he finds himself limited by his small size, his finite (limited) mind, and his short life span in relation to the infinity (limitlessness) of space and time.

LABORATORY EXPERIENCE F.3.a.

Can We Understand Size?

Introduction:

For hundreds and thousands of years scientists were limited by their own senses. They could see stars, the moon, the sun, and the planets. Then the telescope was invented and it was possible to observe many more and more distant celestial bodies. Today the radio telescope makes still more distant bodies "visible." Can the radio astronomer of today observe the "end of space?"

During the seventeenth century, Anthony van Leeuwenhoek discovered "little beasties" in water that appeared clear to the unaided eye. He had used a microscope. Today the electron microscope has enabled scientists to observe smaller and smaller objects. There are definite limits, however, to the size of objects that even an electron microscope can help men to see. Can the microscopist conceive of an instrument that will make it possible for man to see the smallest ultimate unit of matter? Can science invent such an instrument? What is the smallest unit? Do we know what it is? Can we ever be sure there is such a unit?

Materials and Equipment:

Paper and pencil

An imaginative mind

Collecting Data:

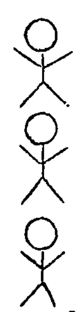
If a man is six feet tall, what part of a mile is he tall?

5,280.0 6.000 ft.

The earth is approximately 8,000 miles in diameter, how does a six-foot man compare with the size of the earth?

8,000 (answer from above)

It is approximately 240,000 miles to the closest celestial body, the moon. How many feet is that? If you stood all residents of the United States on top of one another:



would you reach the moon? The distance from the earth to the sun is called one astronomical unit (a.u.). An a.u. is approximately 93,000,000 miles.

How many six-foot men standing on one another would it take to reach the sun? Are there enough people on the earth today to do this? Find how many a.u.'s it is from the sun to each of the outer planets. How would you go about doing this? What will you need to do first?

Compare these distances with the 8,000 mile diameter of earth. Is your head "spinning" in an effort to conceive of these distances? The nearest star (Centauri Proxima) is 4 1/3 light years from earth. A light year is the distance (not time) that light travels in a year.

186,000	x 60	x 60	x 24	x 365 = ?
mi. per sec.	sec. per min.	min. per hr.	hrs. per day	days per year

How long would it take a rocket traveling 25,000 miles per hour (the escape velocity from earth) to reach Centauri Proxima? Are you reaching the limits of your ability to conceive of vast distances? The scientist is human, too. He also reaches these same limits.

Are you beginning to realize how small man is in relation to known distances? What about other stars in the Milky Way Galaxy? (the galaxy in which our sun is one of about 100 billion stars.) What about other galaxies? What about "endlessness?" Can you "stretch" your mind that far? Can you conceive of a model of a universe that is endless?

Follow-Up:

"Endlessness" in relation to largeness is the antithesis of the other "endlessness" in relation to smallness. Actually "the smallest" and "the largest" are both non-existent, because there are no limits as to size. Find out the size of an electron. Can you conceive of anything one-millionth as large? one billionth? one trillionth? Note: Man is said to be about midway in size between an atom and a star---and between an electron and a galaxy.

Try to see the film "Powers of Ten", produced by the Herman Miller Company.

LABORATORY EXPERIENCE F.3.b.

Walking Back Toward the Beginning

Introduction:

Although the evolution of life on the earth undoubtedly had a beginning, and may very well have an end some day, it is difficult to think of a particular species, such as man, having a beginning, if man is indeed related to other forms of life. It would be easier to believe that man is a special creation, because this would give him a beginning. It would be easier also to believe that man came to the earth as an immigrant from a planet circling some other star. This idea has served as the basis for certain science fiction stories. It also would give man a beginning.

Science, however, presents evidence that man along with all other forms of life, are related as members of one vast "family;" that man is actually physically a kind of "cousin" to lower animals. Therefore, if you trace back any human line, you will come to a point where it merges into a common ancestry with lines leading to related kinds of animals. Where, then, was man's beginning?

Man belongs to a group of animals called primates. These all have teeth that are somewhat like man's, hands and sometimes feet that are capable of grasping and holding objects, finger and toe nails instead of claws, and brains that are larger in proportion to their body weight than those of other mammals. Many of them show some tendency toward the upright posture, like man's. This group includes, along with man and various forms of fossil pre-humans, the anthropoid apes (chimpanzees, gorillas, orang-utans, gibbons), baboons, the tailless Old World monkeys, the tailed New World monkeys, and a couple of generally unfamiliar forms called lemurs and tarsiers.

All of these animals have many genes in common with man. This is indicated by their possession of the same physical characteristics. One study of the extent of the anatomical characteristics possessed in common by man and the anthropoids that are closest to him indicates that he shares:*

385 characteristics with the gorilla
369 with the chimpanzee
354 with the orang-utan
117 with the gibbon
Only 312 are exclusively man's own

This would indicate that the gene pools of humans, gorillas, chimpanzees, orang-utans and gibbons are the same or similar to the extent that their physical characteristics are shared. How do you think the human gene pool would compare with those of cats, horses, lizards, fish, insects? You can think of relationships with members of your own family also in terms of shared characteristics (and genes).

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*Quoted from von Koenigswald, G.H.R., The Evolution of Man, The University of Michigan Press, Ann Arbor, Michigan, 1962.

Materials and Equipment:

A little knowledge of man's past

An active curiosity

An imagination

A copy of the Christian Bible or the Jewish Scriptures

Collecting Data:

Assign imaginary (estimated) percentages, starting with 100% in the case of identical twins, who have identical heredity, to the following relationships:

an identical twin (100%)

an ordinary sibling (brother or sister, not an identical twin)

first cousin (child of a brother or sister of your mother or father)

member of an unrelated family of the same race.

member of a family of a different race

chimpanzee

Old World tailless monkey

New World tailed monkey

cat

lizard

frog

fish

earthworm

snail

jelleyfish

oak tree

What you are really saying is that all living things have some genes in common (or they would not have the characteristics that we call life), but that the number (or percentage) of genes that they have in common are less and less in direct relation to the distance of their kinship.

There is an increasing amount of evidence which indicates that the human species (Homo sapiens) is about 2,000,000 years old. Recent discoveries of human and near-human fossils in East Africa have been determined by the

potassium-argon method of chemical dating to be at least 1,750,000 years old. Still more ancient finds of pre-human fossils, also from East Africa, go back 25,000,000 to 30,000,000 years.*

Ultimately the modern gene pools of man and the anthropoids were all derived from a single ancestral gene pool. The modern ones have diverged from the ancestral one through the operation of mutation and natural selection. It has taken 30,000,000 years or more to produce this divergence. The possessor of the ancestral gene pool that lived 30,000,000 years ago was neither human nor anthropoid, although undoubtedly it showed many of the characteristics of both of its modern descendants.

There are generally about three or four human generations per century in any family line. A boy born in 1964 has a father who was born in 1936, a paternal grandfather who was born in 1908, a great-grandfather born in 1877, a great-great-grandfather born in 1839, a great-great-great-grandfather born in 1805, and a great-great-great-great-grandfather born in 1775. This means that there are about 35 generations per 1000 years, 350 per 10,000 years, 3500 per 100,000 years, and 35,000 per 1,000,000 years. Thus, there have been about 70,000 human generations since man became man around 2,000,000 years ago. Of course, this assumes that the length of human generations has remained approximately the same.

Present-day races of man, along with all of their sub-races and mixtures, belong to a single highly variable species, Homo sapiens. Representatives of an earlier species, Homo erectus, have been found in fossil form in various parts of the Old World. Recently L.S.B. Leakey has discovered what he believes to be the remains of a still earlier species of man, Homo habilis, in East Africa. Representatives of the group of primates which immediately preceded man, called Australopithecines, have been discovered in East and South Africa. Other early relatives of man have been found in various parts of the Old World, but the line seems clearest in Africa.

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*Much of this work has been done by a British anthropologist, Dr. L.S.B. Leakey. Accounts of his research, and that of his co-workers is found in the National Geographic Magazine:

Leakey, L.S.B., "Finding the World's Earliest Man," Vol. 118 (No. 3) pp. 420-435, September 1960.

Ibid. "Exploring 1,750,000 Years into Man's Past," Vol. 120 (No. 4) pp. 554-589, October, 1961.

Curtis, Garniss H., "A Clock for the Ages: Potassium-Argon," Vol. 120 (No. 4) pp. 590-592, October, 1961.

Leakey, L.S.B. and Hugo Van Lawick, "Adventures in Search of Man" Vol. 123 (No. 1) pp. 132-152, January, 1963.

Payne, Melvin M., "Family in Search of Prehistoric Man," Vol. 127 (No. 2) pp. 194-231, February, 1965.

Leakey, Richard E., "In Search of Man's Past at Lake Rudolph," Vol. 137 (No. 5) pp. 712-732, May, 1970.

Many anthropologists believe that each species of man has developed directly out of the species that preceded it. It appears possible, therefore, to trace a direct line of descent backward from modern Homo sapiens, through Homo erectus, then through Homo habilis (if Leakey is correct) to the Australopithecines and beyond.

While we cannot ride a time machine backward along our line of ancestors, we can travel along it in our minds, "seeing" the individuals that are in it with our imagination. Our "picturing" of them in our minds is based on the best information we can get as to what they looked like. We will do our best to follow this long line.

As a preparation for this you should try to find and examine carefully pictures of your parents when they were young, your grandparents, and if possible, your great-grandparents and any still earlier ancestors. You should also examine pictures and restorations, showing people in past centuries, in the Middle Ages, in ancient civilizations, primitive man, earlier forms of man, and prehuman types. Any familiarity which you have with man's past through a study of history will be helpful.

Now, if you are a girl, think of yourself as being the latest of a continuous line of women: your mother, her mother before her and so on back, an unbroken line of females extending backward. If you are a boy, think of yourself as the latest of a continuous line of men: your father, his father before him, and so on back, an unbroken line of males extending backward. Think of the individuals in your line as being all about the same age, about the age of your parents as you know them now.

Now, detach yourself from the head of the line and walk backward in your imagination, observing each person in the line closely as you do so. Remember that you are seeing about three or four generations in 100 years. By the time you have looked at 35 people you have traveled backward 1000 years. By the time you have seen 70 people you will be at about the beginning of the Christian Era in Roman times. With 100 people you will be seeing the people in your line who lived at about the time of Kings David and Solomon in the Bible (900-1000 B.C.)

One hundred and thirty-five generations will put you at about the time in the Bible when Abraham left the city of Ur of the Chaldees (about 2000 B.C.) This city has been re-discovered and excavated by modern archeologists. It was already a city 1000 years old when Abraham lived in it.

Try to tie in other points in your line with periods of history that you know about or can look up. Your ancestors were probably not living in the places where the things you know about or can read about were happening, but they were living somewhere at the same time. Otherwise you would not be here now.

What about the period of the Egyptian and Babylonian civilizations (5000-2000 B.C.)? What about the time of the building of the earliest cities (7000-5000 B.C.)? Of the domestication of plants and animals and the invention of agriculture (10,000-8,000 B.C.)?

As you travel back along the line, observe the general appearance of the people, their degree of cleanliness, clothing, hair style, any ornaments they wear, any tools that they have, any utensils that they use. A visit to a museum will help with this.

Remember that tools, utensils, clothing, devices of all kinds, weapons, even ornaments, evolve in much the same way that living organisms do, but they do so much more rapidly. What kind of food do you suppose your ancestors ate? What kind of language did they speak? Do you think you could have understood them? Does evolution work in these areas also?

You may grow tired "walking," even in your imagination. At about the point where you now are, we will suppose that small, motorized vehicles will be provided. You may ride one of these if you wish. After all, seeing individuals at this point and beyond is less important than getting an idea of the changes that have taken place in the line over fairly long periods.

Ride backward. What do you think you will be seeing in 10,000 years. Remember, this is only 350 generations backward from the point where you left your parents. In 100,000 years? This is 3500 generations. In 1,000,000 years (35,000 generations).

When you have gone back 500,000 years (17,500 generations), you will have left Homo sapiens. In 1,500,000 years (52,500 generations), you will probably have left Homo erectus. In 2,000,000 to 2,500,000 years (70,000 to 100,000 generations) you will probably have left Homo habilis and be looking at Australopithecines.

Somewhere along the way you will realize suddenly, "Why these creatures aren't human! When did this happen?" At this point you may turn your vehicle around and retrace the latest portion of your route more slowly and carefully. Surely, you must have missed something!

Do you think that you will find an answer to your question? Do you think that you will find a place where you can say, "This woman (or this man) is human, but her mother (or his father) was not?" Did man have a beginning?

Follow-Up:

Some people are troubled by possible conflicts between evolution and the Biblical story of creation. However, in the light of what we know about the scientific account of creation, and the broad outlines of the Biblical account, we can look at them in relation to each other. Instead of looking for ways in which they contradict one another, we can look for ways in which they agree. This furnishes a fresh, new viewpoint.

Read the early chapters of the Book of Genesis in the Bible (Chapters 1-9): The broad outline of the creation story in the first chapter of Genesis shows many points of similarity to the broad outline of the scientific account of the world's origin.

1. Both start with a condition of primal chaos (disorder).

2. Both include an early separation of the land masses from the ocean.

3. Both provide for the beginning of life in the seas.

4. Both put plant life on land before animal life.

5. Both tell of gigantic forms of life which existed before the coming of man.

6. Both put the origin of man last.

This indication of parallelism does not involve any attempt to interpret the "days" of creation as periods of millions of years. Any individual is free to do this if he chooses, but to do so is to do injustice to both accounts. It is much better to simply accept the self-evident parallelism and look for possible reasons for its existence.

What do you think may be the basis for this parallelism? Suggest one or more possible reasons for it? Which do you think is the most likely reason? Why?

There are many points of correspondence between the historical materials in the Bible and what archeologists and others have learned about the general development of man and of human civilization in the Middle East. Stories of the Creation and the Flood are found in the written records of other peoples in the Tigris-Euphrates valley. These stories resemble the Bible stories in a general way, and even in some cases in details other than the names of characters. These stories were written before the corresponding stories in the Bible were written, and would indicate that all of the peoples in the area had either had common ancestral experiences or had exchanged accounts of them, and possessed a common fund of ideas concerning the problem of origins. Which do you think is the more probable explanation?

The biblical countries are a good area for the study of man's past, from the days of primitive man or even his prehuman ancestores, right up to a connection with historic times. They constitute one of the few places in the world where there is practically a continuous record, archeological or written, of human living from Early Stone Age times right up to the latest dispute between modern nations.

Skeletons and artifacts of Early Stone Age man have been found in Palestine. Along with their stone implements are the remains of their fires. Some of these early men were possibly hybrids between Neanderthal Man and an early form of the present type of man.

It was in this general area, on the plateaus of Turkey, Iraq, and Iran, and in the adjacent Tigris-Euphrates valley, that agriculture began 10,000 to 12,000 years ago. There wheat and barley were domesticated and the earlist cities were built.

Jericho, at the head of the Dead Sea, was the world's first city. It was built between 9,000 and 10,000 years ago. Its economy was based partly on trade in tar from natural tar pits. These are common in this oil rich country. Another object of trade was salt from the Dead Sea. The tar was used for fastening arrowheads on their shafts. The salt was necessary as people's diet came more to be based on grain grown agriculturally and less on meat.

Remains of the earliest domesticated animals: sheep, goats, hogs, cats, and slightly later, donkeys and cattle, are found in this area.

It was in this area that man learned to work metals, first copper, then bronze and finally iron.

It was in this area that the earliest form of writing was invented, and the earliest written records were kept.

From these early origins the record is continuous in this area through historic times to the present. The record in the Bible consists of the history of one particular group of people in this region in relation to other peoples. This record has been shown to correspond, allowing for some exaggeration due to national prejudice, to the overall historical record of the region as worked out by archeologists and historians. The exaggerations are no greater than those of Americans writing of their own Revolutionary War, as compared to the story of the same events written by the British. Details differ, and the relative importance attached to particular events varies, but the broad outline is the same.

We can therefore ask ourselves where, at what point or level, the earliest characters of the Bible fit into this picture. We can best answer this question by going back to what the Bible says about them.

Cain was an agriculturist. Abel was a herdsman. After Abel's murder, Cain fled to a country to the east of Eden and married a wife there. Later he built a city and named it in honor of his son. One of his descendants in the sixth generation was a worker in brass and iron.

Taking the narrative at its face value, these details tell us that at this time there were people on the earth other than the immediate descendants of Adam, neighboring tribes with whom a criminal could find asylum. They tell us furthermore that domestication of plants and animals had already taken place, and that men had begun to live in towns. They also tell us that metal working, specifically the working of brass and iron, was known but probably was not common, since it is specifically mentioned. These things date the period of the early Bible characters very definitely in relation to the development of human culture in the area.

The ages given for the early Biblical partiarchs have raised interesting questions. Largely on the basis of them one authority, Archbishop Usher, worked out a chronology in which he indicated that the creation of the world took place on October 12, 4004 B.C. We know now that many early peoples reckoned time by the monthly <u>lunar cycle</u> rather than by the <u>annual cycle</u> that we use now. Their year was a month. Our own Indians reckoned time in "moons." Since there are thirteen lunar months of 28 days in one of our years, a division by 13 of the age given in "years" for the oldest patriarchs should furnish a correction. It gives results comparable to the ages to which modern men live. What were the <u>real ages</u> in <u>our years</u> of the patriarchs listed in Genesis, Chapter 5? Of Noah (end of Chapter 9)?

Read on in the Book of Genesis. You will find it to be a very interesting story about very <u>human</u> people. "Genesis" means "beginning."

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Read on in the Book of Genesis. You will find it to be a very interesting story about very human people. "Genesis" means "beginning."

LABORATORY EXPERIENCE F.3.c.

Time Enough and to Spare!

Introduction:

It is difficult to think of endless time---eternity. Yet it is a concept that is commonplace in religion. Did you ever try to think about it, and what it might be like? Would "forever" be a steady state---unchanging, always the same? (Wouldn't it be uninteresting, if it were like this?) Would it be an endlessly recurring cycle---always repeating itself? (Maybe the cycles might be so long, that each cycle itself would seem endless to those in it.) Would it be infinitely variable, never two moments the same---patternless? What about the possibility that it would be long enough for anything that can happen, no matter how rarely, to happen, not once, but again and again, an infinite number of times? If we think of it in this way, can we make a mental model of eternity?

Materials and Equipment:

10 pennies

A pack of playing cards

An imagination

Collecting Data:

Toss ten pennies at once. What pattern of heads and tails do you get? (How many of each?) Now do it again, and continue to do it until you get the same pattern again. How many times do you have to toss them? Do it again and again until you get the same pattern a third time---a fourth time---a fifth time. Keep on until you have gotten the same pattern ten times. How many times have you had to toss the pennies in order to get the same pattern ten times? On this same basis how many times would you have to toss the pennies to get the same pattern a hundred times? A thousand times? A million times? If you toss the pennies an infinite number of times would you get the same pattern an infinite number of times? What about other possible patterns?

A deck of playing cards contains 52 cards. These consist of four "suits" (kinds) of 13 cards each. In each suit the cards have spots on them from one to ten, and then there are three "face cards" distinguished by the pictures on them, called "king", "queen" and "jack" or "knave." The four suits are distinguished by the shape of the spots: "hearts" and "diamonds" (both red), and "spades" and "clubs" (both black).

In the game of bridge there are four players. These players deal out all 52 cards, so that each player holds 13 cards. These 13 cards constitute a "hand." A hand may consist of any combination of 13 cards in the deck.

In teams of four, try this out. NOTE: You do not need to know how to play bridge! What combination of cards does each member of the team get? Shuffle the cards and try it again. Keep doing it again and again. Do it 100 times. Do you get a repetition of the first pattern in 100 attempts?

How many attempts do you think you might have to make in order to get a repetition of the first pattern? Why? What about other patterns? Would you get an infinite number of repetitions of all patterns in an infinite number of attempts?

Why do you think it was easier to get a repetition of the first pattern in the case of the pennies than in the case of the cards?

What about a still more complex pattern? Are you such a pattern? You are what you are right now; not any of the other possibilities that you might have been. What if you had done that other thing when you did this instead? Did you ever think: "If I had gone on that trip I might have been hurt or killed in the accident that occurred?" "If my parents had not moved to this city when they did, I would never have known so-and-so who has meant a great deal to me?" How many other "ifs" can you think of? The other possibilities are other patterns, other "yous" that might have been.

Do you think that in the infinite length of eternity you as you are now might ever occur again? How likely do you think such a recurrence might be? How unlikely? How about the other "yous?" Would you get an infinite number of recurrences of "you" as you now are, and as you might have been, in the infinite length of eternity?

Does thinking in this way help you to think of eternity as endless time?

Follow-Up:

If time is infinite forward and backward, have we existed before? Will we exist again? If space is infinite, do we exist somewhere else right now? Think about infinity as the beginninglessness and endlessness of time and space.

LABORATORY EXPERIENCE F.3.d.

The Faster You Go The Slower Time Goes

Introduction:

According to Einstein's Theory of Relativity, the velocity of light (186,000 miles per second) is the greatest velocity that it is possible for anything in the universe to attain. Furthermore, as velocity increases toward the velocity of light, mass approaches infinity and time approaches zero. This is difficult for our limited minds to comprehend. How could an object possess infinite mass? How could there be zero time? We cannot think of mass in terms other than limited ones---so many pounds, or tons, or kilograms. We cannot think of time other than in terms of duration, of seconds, minutes, hours, centuries. Time always moves forward. It never moves backward and it never stands still.

Yet the forward movement of time apparently does slow down as velocity increases, and mass apparently does increase as velocity is accelerated. Experiments which have been carried out in the laboratory show both of these events occurring. Time slowed a little for the astronauts during their trip to and from the moon. This means that "shiptime" went a little more slowly than "earth time." The slowing down of shiptime was in direct proportion to the velocity of the ship.

According to the Theory of Relativity the more closely the velocity of light is approached the greater is the slowing down of time. Most of the slowing down toward zero takes place after a velocity of 180,000 miles a second is passed. In thinking of this it is well to remember that the astronauts had only to attain a velocity of 25,000 miles an hour to escape the gravitational pull of earth.

Materials and Equipment:

Pencil and paper or other equipment for a few simple mathematical calculations

Collecting Data:

Most physicists do not believe it would be possible for a ship to actually attain a velocity of 186,000 miles a second, but it is conceivable that a ship might some day be built that would come close to it. Let us imagine that such a ship could travel 185,000 miles a second, and that at such a velocity time was slowed to one percent of its usual duration.

It is 4.3 light years to the nearest star (Centauri Proxima). A light year is the distance that light travels in a year (365 days x 24 hours x 60 minutes x 60 seconds x 186,000 miles). Calculate how far away the nearest star is in miles. Then find how long it would take a ship traveling at 185,000 miles a second to reach it. This will give you the actual time that it would take the ship to get to Centauri Proxima as observed through a telescope on Earth ("earth time"). But time for the men on the ship ("ship time") would be slowed down 99 percent. Therefore it would seem to them only

one percent as long as it did on Earth. According to the Theory of Relativity they would grow older only one percent as rapidly as they would if they were on Earth. How much older would they become while they were traveling?

Assume that these men landed on a planet circling the star and moving in its orbit at the same velocity as Earth does in circling the sun. Assume that they stayed there for 6 months and then returned to Earth traveling at the same velocity they did on the outbound trip. How much younger would they be than their friends that they left on Earth who were the same age as they were when they went away?

Follow-Up:

The moon goes around the earth while the earth is going around the sun. Therefore the moon must travel at a velocity greater than that of the earth. If a colony were established on the moon, do you think that the people living in it would grow old more slowly ("moon time") than those who remained on the earth ("earth time"). Do you suppose the astronauts did this during the few hours that they were on the moon?

Most stars that we can see in the night sky are 20 or more light years away. The nearest galaxy (star group) which is disc-shaped or wheel-shaped like our own is the Andromeda galaxy. It is 750,000 light years away. By a calculation similar to the one that you made with reference to Centauri Proxima, determine whether it would be possible for astronauts to make a round trip to the Andromeda galaxy in a normal life span of "ship time." Assuming that their lives could be long enough for them to complete such a trip, how many years of history would have passed on earth while they were gone?

Science fiction writers sometimes imagine that a new physical principle may be discovered by which it will be possible for a space ship to travel at speeds faster than the velocity of light. They refer to a ship using this principle and traveling faster than light as being "in overdrive." If time is zero (stands still) at the velocity of light, do you think that astronauts on a ship in overdrive would find time going backward for them? Might they be growing younger?

According to Hubble's Theory of the Expanding Universe, all galaxies are constantly getting farther apart, and traveling faster and faster as they do so. As they do this, they approach the velocity of light. If they ultimately attain the velocity of light, we would not be able to see them anymore, even if we had telescopes powerful enough to look at them at the great distance. Why couldn't we see them? What do you think might happen to them when they reach the velocity of light? Of course you have no data to answer this last question, but neither does anybody else. You are free to think about it. Can you stretch your mind this far?

IDEA-CENTERED LABORATORY SCIENCE

(I-CLS)

Unit F. A Scientist Looks Critically at His World

TEACHER NOTES

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Unit F. A Scientist Looks Critically at His World

TEACHER NOTES

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LABORATORY EXPERIENCE F.1.a.

Poetry and Science

TEACHER NOTES

This laboratory experience is an attempt to get the student to do two different kinds of thinking in relation to the same problem. One of these is the kind of thinking a poet does, and the other is the kind of thinking a scientist does. Then an attempt is made to look at the two together and compare them.

This experience is capable of almost limitless expansion. Other poems can be used. These do not have to be poems about objects in nature. They can deal with ideas, either ideas about nature or other ideas. Kinds of literature other than poetry can be used. Almost anything in the whole wide range of human thought is capable of thus being looked at in two different ways. This is important in connection with a person's daily living because all of us live in "two worlds" at the same time.

LABORATORY EXPERIENCE F.1.b.

Music and Sound

TEACHER NOTES

This laboratory experience gives students an opportunity to think about sounds in terms of characteristics that can be measured and those that can only be "felt." Here again is something that may be looked at in two ways. Of course the scientist may also be a music lover. The two aspects do not interfere with one another.

As in the case of other examples of the "two worlds" in which we live, this situation, when it is made clear to students, may serve as a basis for interesting class discussions.

LABORATORY EXPERIENCE F.1.c.

Art and Reality

TEACHER NOTES

This experience is designed to examine various ways of looking at the world. The scientist's way involves exact description of detail, picturization, and measurement. The artist's way puts something of the artist himself into the description or picture. Students should be encouraged to look at nature both ways in as many cases as possible. They may become better scientists (or science appreciators) and at the same time better artists (or art appreciators) as a result.

LABORATORY EXPERIENCE F.1.d.

Study of Motion and Interpretive Motion

TEACHER NOTES

Demonstrate Newton's Laws of Motion in the laboratory with simple equipment. This will help students to make the laws of motion a part of their thinking. It will be helpful to have students attempt through motion to imitate various kinds of animal motion, just as kindergarten children might do. Also have them try to imitate interpretively modern devices such as automobiles, space ships, power lawn mowers. These things can be done as charades; having others try to guess what they are supposed to represent.

LABORATORY EXPERIENCE F.1.e.

Science and Dramatics

TEACHER NOTES

The goal of this laboratory experience is to give teacher and students an opportunity to discover for themselves the relationships and limitations which lie at the interfaces of science and dramatics. They can do this from the standpoint of the extent to which these are dealing with the same aspects of human behavior or different aspects----Whether they overlap or are entirely separate. Both are legitimate approaches to the problem of meaning in our world.

Students should be given ample opportunity to explore these questions through individual thinking and class discussions. They should give thought and consideration to the possible emotional content of science, and the possible scientific study of emotions.

LABORATORY EXPERIENCE F.2.a.

A World of Magic

TEACHER NOTES

An attempt is made in this story to set up a situation in which an alien ideology serves to limit the freedom of a scientist. It is actually true that magic had its "laws" which magicians themselves and many other people who were not magicians believed "worked" in somewhat the same way that we believe scientific laws "work." It is also true that the world of magic of a thousand years ago constituted a real challenge to medieval Christianity. However, there never was a Martinus Gerardus.

The idea of alternative worlds has no real basis of which we know. All of us, however, may speculate "what if---." Considering this story and the implications involved in it should furnish a basis for lively class discussion.

LABORATORY EXPERIENCE F.2.b.

Could We Produce a Superior Strain of Man?

TEACHER NOTES

The reason the experiment would fail is this: Improved strains of domestic animals, and plants, such as dairy cows that produce record amounts of milk and butterfat, beef cattle that gain weight rapidly, hens that lay more than one egg per day for a year, dogs that are particularly intelligent for hunting or herding sheep, or corn that produces high yields, can only do these things when they are kept in special environments that are created and maintained by man. Most of them would quickly become extinct if man did not artificially maintain them.

Even if they survived, their special characteristics could not be expressed. If they were expressed, they would generally be a handicap to survival. They would be disadvantageous rather than advantageous. The improved strains if they survived would revert quickly toward the norm of the species.

The only way, that the improved strain of humans could be maintained would be to keep them in special environments. The only people who could do this would be the general human population---the common "garden variety" of man that we all belong to.

LABORATORY EXPERIENCE F.2.c.

Three Score and Ten

TEACHER NOTES

This story can either be read by the children or read to them. It would be a good idea to have them read it or hear it one period (or as home work) and discuss it the following period. The issues, social and moral, which are raised by it are profound, and yet they life squarely in the direction in which our culture is headed. The length of human life expectancy has approximately doubled in this century. With continued medical discoveries it may well double again in another century.

Other "follow up" questions, of course, could be euthanasia and population control, by various available methods. You may or may not wish to go into these in your classroom. However, once the door is opened by this story, your class may well force their consideration. In any case you should be prepared for some of these likely leads by doing some thinking about them yourself.

LABORATORY EXPERIENCE F.2.d.

If We Could Go Back

TEACHER NOTES

This laboratory experience gives students an opportunity to examine their own value systems in relation to our science-based society. If time travel were possible we would be faced with many such dilemmas. Students may well have an opportunity to increase their knowledge of history and to make it meaningful through this experience.

LABORATORY EXPERIENCE F.2.e.

The Twenty-Sixth Century

TEACHER NOTES

This laboratory experience gives students an opportunity to think about the kind of society that is necessary for science to carry on its activity in searching for truth concerning the natural world. Do we have such a climate? Does anybody?

LABORATORY EXPERIENCE F.3.a.

Can We Understand Size?

TEACHER NOTES

As with a great many of the I-CLS experiences, the goal of this experience is to get students to think and stretch their minds. The suggested activities are capable of much expansion. Any activity which contributes to the goal of "mind-stretching" may be used. Students and teacher should try to conceive of the idea of endlessness in terms of size, both "large" and "small," even if they cannot really do so.

Also the business of relationships enters here. We have dealt with it before: the relationship of sizes and units of measurement to the observer, and his relationship to the thing being observed. An astronomical unit becomes meaningless when distances on earth are considered, even though it would be possible to express the distance from New York to San Francisco as a fraction of one astronomical unit. Likewise the height of a man becomes ridiculous when considering the distance to the nearest star.

LABORATORY EXPERIENCE F.3.b.

Walking Back Toward the Beginning

TEACHER NOTES

This laboratory experience is almost purely mental. It involves an active exploration of man's past. However it calls for reading background material, and it may be supplemented by museum visits and other kinds of expansion of the students' knowledge of history. An ample amount of the background material is readily available. The only difficulty is that students are not in the habit of reading the sources or doing the things that the laboratory experience calls for.

It will be necessary for the teacher to lead them to and into the suggested sources. In doing this the teacher may also become more familiar with these sources.

The exercise of imagination in picturing man's past will also be a new experience for the students and possibly also for the teacher. Tieing this experience to one's own ancestral line dramatizes it and personalizes it. Anyone can do this. It is an interesting thing to do.

LABORATORY EXPERIENCE F.3.c.

Time Enough and to Spare!

TEACHER NOTES

This laboratory experience is an attempt to help the student to think in terms of infinity. For this a model is needed. The pattern of coins, then the pattern of cards, and finally thinking of himself as a pattern, and of eternity as long enough for even the most complex pattern to be repeated not once, but an infinite number of times---this series of experiences furnishes such a model.

LABORATORY EXPERIENCE F.3.d.

The Faster You Go The Slower Time Goes

TEACHER NOTES

This is a mind-stretching experience which is based on sound physical and astronomical data. The mathematics involved in it is only simple arithmetic. You may have to help students set it up, but they will enjoy the thinking involved in it. It is a favorite theme for science fiction writers. If you wish to go beyond the suggested "follow-up", you might have them try to think up a science fiction plot based on the lab experience.

Remember that only one percent of 750,000 years of "earth time" will pass for the men on the ship going to Centauri Proxima and the same for the return trip. Therefore a close approximation to the correct answer to the question asked in the "Follow-Up" can be obtained easily and quickly by finding one percent of 750,000 years and multiplying it by two. If you use this short method, be sure to stress that it results in an approximation. Then, if you wish, have the students go ahead and figure out the actual answer and compare the two.